of direction is manifest in the unconscious tendency to curve to the right or left in walking when blindfolded. My experiments with forty-nine young men show (*Nature* XXXII., 293; SCIENCE XV., 14) that this divergence from a right line is not owing to differences in the length, or strength, or dexterity of the legs, the physical factors that suggest a convenient explanation of the phenomena, but to a lack of coördination in the muscles of the legs, arising from the defective supervision of their movements by the senses.

The ability to walk in a given direction and the proper interpretation of the inverted image on the retina are alike determined by the activities of the brain, including the central sense organs, and physical considerations relating solely to the peripheral organs concerned, which take into the account but a single factor in a complex problem, cannot be accepted as furnishing satisfactory explanations of physiological processes. MANLY MILES.

LANSING, MICH., November 27.

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## *SCIENTIFIC LITERATURE.*

*Elements of the Mathematical Theory of Electricity and Magnetism.* By J. J. THOMSON. Cambridge University Press. New York, Macmillan & Co. 1895. Crown 8°. Pp. vi. 510.

*Electricity and Magnetism. A Mathematical Treatise for Advanced Undergraduate Students.* By FRANCIS A. NIPHER. St. Louis, John L. Boland Book and Stationery Co. 1895. Crown 8°. Pp. xi. 426.

Prof. J. J. Thomson is well known as the worthy successor to the chair of Maxwell and Lord Rayleigh. He has been hitherto known chiefly for his work in mathematical physics, and latterly for his numerous experimental researches. This book exhibits him in a new light, namely, as a teacher of elementary students, and plainly declares him a master in that domain. The subject of 'Electricity and Magnetism' is one that lends itself readily to applications of many of the most difficult portions of analysis, and it is generally supposed that an exact comprehension of the various essential parts of the theory is only to be attained by those persons who possess a thorough mathematical training. Maxwell's great work is a bugbear to many a student on account of the mathematical difficulties which it undoubtedly contains. How mistaken the idea is that the essentials of the theory cannot be presented to a person of but slight mathematical training, a perusal of this delightful book will show. The reviewer often recalls the words of one of his old professors in college, who was wont to ask the student who had successfully deduced some differential equation to 'translate that into English.' Prof. Thomson's book consists in doing exactly this for the whole theory of Electricity and Magnetism. In this respect it marks almost a new departure in text-books, for while we are familiar with books which, by leaving out difficulties, and by the use of the process known in England as 'Calculus-dodging,' attempt to attain simplicity, we have never before come across a treatment at the same time so full, so clear and exact, of this particular subject. There are, to be sure, two examples of this style of book. If one were asked to name the best English treatise on Thermodynamics he would still have to answer, Maxwell's 'Theory of Heat.' And yet Maxwell's 'Heat' contains very few mathematical symbols. Still if one thoroughly understands the essential principles contained in the book, and has a thorough knowledge of mathematics, he will be well able to write the mathematical treatment for himself. A second example is Maxwell's 'Elementary Treatise on Electricity,' of which we are at once reminded by the present work. Maxwell, however, there treated but a small portion of the subject, principally electrostatics. What Maxwell would have written had he lived to the present day, and treated of Magnetism and the Electromagnetic Field in general, would have probably resembled what Prof. Thomson has given us. This is perhaps a sufficient compliment, but we are tempted to use the trite illustration of the 'flower from the crannied wall,' and say that if one fully comprehended the 'all in all' of this book, he would be possessed of what is worth knowing of the modern theory of electricity, and with the help of a sufficient knowledge of Green's Theorem and the properties of definite integrals he could spin it out into two thick volumes of mathe-

matical treatment. How then has Prof. Thomson managed to strip off the mathematical dress and to present the naked facts? First, by a thorough familiarity with the mathematical treatment which has enabled him to seize the essential, in spite of disguise, and secondly by an unusual gift of exposition. It is only the thorough knowledge of mathematics that enables one to express mathematical truths in plain language. It is a very common opinion that a great talent for research is incompatible with excellence as a teacher. Unfortunately many instances may be cited in support of this proposition, but we contend that it is by no means necessarily true. The same faculties that make one eminent in research should also go to make him successful as a teacher. For either is necessary first enthusiasm, then a thorough acquaintance with the subject, while the teacher needs in addition only the power of saying what he has to say. Given a good style, and something to say, with a wish to teach, and we cannot see what more the teacher needs. Our present author is an example in support of our contention.

Where all is so good it is difficult to select special portions for commendation. We will, however, mention a few matters not usually well treated in elementary books. The parallel treatment of dielectrics and magnetizable bodies is clearly carried out, and the distribution of the energy in the medium, of fundamental importance in the modern theory, is carefully deduced. We are gratified to notice that the author uses in quantitative statements the expression *(unit) tubes of force*, rather than the usual *lines of force*. The inappropriateness of denoting the flux of induction in a dynamo by so many *lines* is illustrated by a recent letter to one of the technical journals, in which the writer makes the luminous remark that the dimensions of the unit of induction cannot be as usually and correctly given, because the dimensions of a *line* are the same as of a *length!* It seems to us to be regretted that Prof. Thomson has here, as in his large volume, made use of the term 'Faraday tubes' to denote tubes of electrical induction. Magnetic tubes are certainly as much due to Faraday as electric. The chapters on fields of force are illustrated by numerous diagrams, some of them new. The confusing matter of magnetic force and magnetic induction is made plain, and the uniform magnetization of a sphere and of an ellipsoid worked out. The statement may be noticed that a long ellipsoid tends to place itself along the lines of force in a uniform field, whether magnetic or diamagnetic. It is so frequently stated in text-books that a diamagnetic body tends to set itself across the field that this will surprise many. The setting across usually observed comes from the lack of uniformity in the field, diamagnetic bodies being repelled from stronger to weaker regions. The correct statement was made forty years ago by Lord Kelvin, who stated, however, that the force tending to make diamagnetic bodies set along the field was probably too small to be observed. It has been observed by the present writer, and the method of observing its influence upon the time of swing of an ellipsoid has been suggested as a means of determining the permeability of diamagnetic bodies, and is now being carried out by one of his students, Mr. A. P. Wills.

Prof. Thomson gives a good treatment of electrolysis and of the electromotive force of batteries, but we think that the fact that the electromotive force can be calculated from the chemical work in the manner stated, only when the cell has no temperature coefficient, should not have been omitted. In the chapter on induction the similarity of the system of currents to a mechanical system is well brought out, and a new and very simple model described. It consists of three weights, hung from carriages rolling on three parallel rails, and kept in line by a straight bar passing through swivels on the carriages. The velocities of the outside carriages being independent, the system may be assimilated to two currents. On account of the third mass, the kinetic energy contains a term in the product of the velocities of the outside carriages, and this term gives rise to the phenomena resembling mutual induction. For instance, if one carriage is started the other goes backward, and when both are moving with constant velocities, if one is arrested the other goes faster. The disadvantage of the model comes from its simplicity, in that the coefficients of induction are constant, so that electromagnetic

forces cannot be shown, nor can induction by motion of the circuits without alteration of the currents. This can be made possible by a simple alteration. If the middle weight, instead of rolling on a fixed rail, roll on the bar connecting the two outer carriages, the coefficients of induction will vary with the position of the middle mass, and moving it along its bar while one of the outer masses is moving will cause the other to move, etc. The centrifugal force tending to make the middle mass roll along its bar will represent the magnetic force between the currents.

A number of interesting cases of induction are worked out, including a simple case of 'throttling of an alternating current' and various practical problems connected with transformers. The explanation of Elihu Thomson's interesting repulsion experiments is also simply given. Various electromagnetic measurements are worked out, including several methods of 'determining the ohm.' Finally the effects of dielectric currents are treated, and the motion of the 'Faraday tubes' and of the energy through the field. The case of propagation of plane electromagnetic waves is taken up, and the experiments of Hertz described. All this with the assumption of no more mathematical knowledge than 'an acquaintance with the Elementary principles of the Differential Calculus.' The reviewer was so struck with the absence of integral signs in the book that he counted them, and was surprised to find that there were actually fifty. Of differential equations there were, however, eighty-six. It will be granted, however, that in a book of over five hundred pages this is not too many. To return to the question of how this is done: It is, after all, by stating facts in language which, while avoiding the notation of the calculus, employs its essential concepts. We question somewhat whether this is not putting on an appearance of simplicity that is but apparent. For instance, it seems doubtful whether the expedient of dividing an area up into meshes, multiplying the force by the area of each and adding, is to be preferred to using the term surface integral in the first place. The method of the book may be characterized as that of dealing with phenomena in infinitely small pieces. It only remains to use the language of limits and to integrate in order to have a complete treatment. If the author may be accused of calculus-dodging, however, he has done it so well that he may be forgiven, and the student is bound to be pleased. We can only congratulate those students who have the good fortune to study this subject under the personal guidance of Prof. Thomson, and we predict a large sale for the book.

Of Prof. Nipher's book, a number of the statements already made of Thomson's may be made. In spite, however, of the word 'advanced' in the sub-title of the former, and of the word 'elementary' in that of the latter, it must be admitted that Thomson's contains a good deal more meat. Prof. Nipher states also that his book "is designed for the use of students who have but recently begun to use the processes of the calculus, and it has been an incidental aim of the author to assist the pupil in acquiring possession of the machinery of mathematics. There has been no attempt to avoid any legitimate analytical method because it is not popularly known, but on the other hand there has been an attempt to avoid wasting the time of the reader over puzzles and obscurities which are made difficult and called easy." This attempt has certainly been carried out. The student will not waste his time if he reads this book. It has evidently been written with a view to the needs of the engineering student, who has been almost ignored by Prof. Thomson. It will do this engineering student good to read Prof. Nipher's chapter on electrostatics, and on energy, even if they do not assist him to design dynamos. Here again we have the parallel action of dielectrics and magnetizable bodies clearly brought out, a matter which can hardly be too strongly emphasized. Prof. Nipher recently announced the existence of 'Ohm's Law' for dielectrics as if it were something new, whereas the matter must have been evident to anyone familiar with the geometrical meaning of Laplace's equation, and was, if we mistake not, known to Faraday. Prof. Nipher has also taken the pains to invent the terms perviance, diviance and perviability, to denote the electrostatic analogues to conductance, resistance and conductivity. We trust that this will not go on to all the cases in which similar

quantities occur in mathematical physics. Du Bois, in his book on magnetic circuits, has given a table of six cases. Prof. Nipher's discovery was effusively welcomed by Prof. Silvanus Thomson, but it was amusing to find one of the English technical journals editorially refusing to admit its truth, on the ground that the current from an electrode in the form of a spherical bowl in an infinite conductor would probably not be distributed in like manner to the lines of force from an electrified bowl in air.

After the chapter on electrostatics, of the large number of examples worked out, nearly all are of practical interest. In fact, the principal complaint that we have to make of the book is that it seems written for engineering students. Practically, of course, this is the reverse of a disadvantage. There is a large amount of arithmetic in the book, which again, although repulsive to some in an 'advanced' book, will be very welcome to many. There are a number of excellent figures, some of them quite original, an interesting one being of a surface showing the doubtless dependence of the strength of an alternating current on self-induction and capacity. Although the dynamo and transformer, including the tri-phase system, receive ample treatment, there is, for those who do not find examples enough in the body of the book, a chapter of well selected problems at the end. There is also a chapter on units, in which both systems are treated, although nothing is said about keeping $\kappa$ and $\mu$ in the formulas. The names given the practical units by the American Institute of Electrical Engineers are mentioned. We notice the curious spelling 'culomb,' which seems neither fish, flesh nor fowl. Each of the above books has a good index. In conclusion we may be permitted to express the wish that every student of electrical engineering might learn at least as much theory as is contained in one or the other of these books. We hope that their appearance will not cause anyone to suppose that Maxwell may now be laid on the shelf.

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WINGE ON BRAZILIAN APES.

MR. HERLUF WINGE has recently published his fourth paper on the mammals of the province of Minas Geraes, Brazil.* In this quarto of 45 pages the author deals with the Primates as he has already treated the rodents, bats and marsupials. The material on which the present study is based was brought to the Zoölogical Museum in Copenhagen by Lund and Reinhardt.

As in the earlier numbers of the series, this paper consists of three parts: (1) nominal lists of the species; (2) a detailed enumeration of the species, with critical notes on the relationships of the forms whose remains are found in the cave deposits ('Jordfundne'), and those now living ('Nulevende') in the immediate vicinity of the caves; (3) a review of the mutual relationships of the members of the group.

The paper is illustrated by two plates reproduced from photographs of actual specimens. While the results attained by this process are not as uniform as could be desired, the figures on the whole are satisfactory, especially those of the skull of *Callithrix.*

Five species of apes are represented in the collections, *Callithrix personata*, *Mycetes seniculus*, *Hapale penicillata*, *Cebus fatuellus* and *Eriodes brasiliensis* (*Eriodes 'propithecus'* Winge). Four of these are found both in the cave deposits and living in the vicinity of the caves. Except in the case of *Callithrix personata* the cave bones agree perfectly with those of recent specimens. The single femur of *Callithrix* found in the Lapa da Serra das Abelhas is slightly larger than that of living examples and has the ridges for muscular attachment rather more sharply defined, but is not specifically distinct from *C. personata.* The only extinct species is *Eriodes brasiliensis* (Lund), the living representatives of which occur in extreme southern Brazil.

Mr. Winge applies the new specific name *propithecus* to *Eriodes brasiliensis* because the other species of the genus are also Brazilian, and because the term *propithecus* originally proposed by Lund as the generic name for a group now considered congeneric with *Eriodes* should

* *Jordfundne og nulevende Aber (Primates) fra Lagoa Santa, Minas Geraes, Brasilien.* Med Udsigt over Abernes indbyrdes Slægtskab. Af HERLUF WINGE. Aftryk af 'E Museo Lundii,' en Samling af Afhandlinger om de i Brasiliens Knoglehuler af Professor Dr. P. W. Lund udgravede Dyre- og Menneskeknogler. Paa Carlsbergfondets Bekostning udgivet ved Professor Dr. C. F. Lütken. Kjöbenhavn, 1895.